143684

Implementation of Hydrologic Models At Goddard Space Flight Center

Final Report

IBM

Implementation of Hydrologic Models At Goddard Space Flight Center

Final Report

31 December 1974

IBM No. 74W-00323

Contract No. NAS5-20597

Prepared for
Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt, Maryland

IBM Federal Systems Division, Space Systems, Huntsville, Alabama

TABLE OF CONTENTS

SECTION 1

INTRODUCTION

The objectives of the project reported by this document were to (1) implement two major watershed simulation models on the computer system at NASA Goddard Space Flight Space Center, (2) verify operation of the models and (3) instruct GSFC personnel in use of the models. These objectives were achieved. Each model was calibrated to represent a watershed located in Maryland. This was the first major step in an ongoing program of implementing several different hydrologic models at GSFC to support continuing investigation of the applicability of remotely acquired (i.e., satellite) data to hydrology.

The project did not involve detailed investigation or development of new techniques. The two hydrologic models -- the NASA-IBM model and the National Weather Service River Forecast System (NWSRFS) -- had previously been developed. Project activity consisted of (1) acquisition of historical and physiographic data for two Maryland river basins (Monocasy River above Jug Bridge and Patuxent River near Laurel, Maryland); (2) calibration of the NASA-IBM model and the NWSRFS to simulate the Patuxent River and Monocasy River basins, respectively; (3) implementation of both models on the computer system at GSFC; and (4) instruction of GSFC personnel in model operation.

The scope of this report is appropriate to the nature of the project; it documents completion of contract activity. Technical information (computer printouts from simulation runs) associated with the project has been provided separately to the NASA Technical Officer. Documents describing model concepts, operation and application are separately available and simply listed for reference in Sections 2 and 3.

SECTION 2

NASA-IBM WATERSHED SIMULATION MODEL

2.1 DESCRIPTION REFERENCES

One of the models used in the study is a highly automated derivative of the well-known and widely-used Stanford Watershed Model IV. Basically a multi-year model applicable to small watersheds, it has previously been modified for simplification to a one-year (rather than multi-year) simulation, introduction and verification of a snowmelt routine, and adaptation to regional watershed simulation by incorporation of a subwatershed streamflow routing routine.

In operation, the model implements a moisture-accounting flow, distributing input (precipitation and snowmelt) among storages (vegetative interception, soil moisture, ground water, snowpack, channel flow, overland flow), losses (evapotranspiration) and output (streamflow from the basin mouth where the stream gage is located). The model produces tabulations and plots of simulated and observed (or reference) streamflow as well as statistical analyses and summaries.

Documentation of the model, as modified and used by IBM, is not complete. Flow charts and listings have been provided to NASA, and additional documentation will appear early in 1975 under another contract. The following references provide information on the background, predecessor models and applications of the version implemented at GSFC.

1. Crawford, N. H. and Linsley, R. K., The Synthesis of Continuous Streamflow Hydrographs on a Digital Computer, Stanford University Department of Civil Engineering, Technical Report No. 12, July 1962.

2. Crawford, N.H., and Linsley, R.K., Digital Simulation in Hydrology: Stanford Watershed Model IV, Stanford, California: Stanford University, Department of Civil Engineering, Technical Report No. 39, July, 1966.

3. Hydrocomp International, "HSP Operations Manual," Palo Alto, California, 1969.

4. James, L.D., An Evaluation of Relationships Between Streamflow Patterns and Watershed Characteristics through the Use of OPSET: A Self-Calibrating Version of the Stanford Watershed Model, Lexington: University of Kentucky, Water Resources Institute. Research Report No. 36, 1970.

5. Liou, E.Y., OPSET: Program for Computerized Selection of Watershed Parameter Value for the Stanford Watershed Model, Lexington: Univeristy of Kentucky, Water Resources Institute, Research Report No. 34, 1970.

6. Ross, G.A., The Stanford Watershed Model: The Correlation of Parameter Values Selected by a Computerized Procedure with Measurable Physical Characteristics of the Watershed, Lexington: University of Kentucky Water Resources Institute, Research Report No. 35, 1970.

7. Stiffler, W.D., "User's Manual for the Colorado State University Version of the Kentucky Watershed Model," Colorado State University, published under NASA Contract NAS9-13142, September 1973.

8. Ambaruch, R., and Simmons, J.W., "Application of Remote Sensing to Hydrology," Final Technical Report, IBM No. 73W-00387, September 1973, for NASA George C. Marshall Space Flight Center (NASA CR-120278; NTIS Accession No. N74-27811).

A suitable summary of model operation and applicaton appears in Volume II of the Final Report on NASA-GSFC Contract NAS5-21942, "A Study of Remote Sensing as Applied to Regional and Small Watersheds."

2.2 WATERSHEDS MODELED

The NASA-IBM model was calibrated to represent two Maryland river basins, designated (1) Patuxent River near Laurel, Maryland, and (2) Patuxent River near Unity, Maryland. The latter (34.8 square miles) is actually included in the former (132 square miles) having its stream gage above the two large reservoirs. Data were acquired for these basins as follows:

- Physiographic Data
  - topographic maps
  - reservoir operating information (capacity, limits on outflow rates, etc.)
  - soil information
- Hystorical Data
  - daily streamflow (discharge)
  - precipitation, from hourly and daily stations
  - evaporation statistics
  - temperature.

The data were acquired, formatted and preprocessed to provide inputs to the model. Physiographic data were used to quantify basic watershed parameters, and then calibration runs were performed to estimate a best set of the remaining parameters. Then the model was implemented in the System/360 Model 91 computer at GSFC and its operation verified from the Model 2741 terminal using the GSFC Conversational Remote Batch Entry (CRBE) System.

2.3 SUMMARY OF RESULTS

The presence of the Triadelphia and Duckett reservoirs prevented successful calibration of the larger basin, with respect to streamflow at the gage (below the lower reservoir). A simple algorithm to represent reservoir action was constructed, coded and integrated into the model. Successful simulation of reservoir effects requires objective, specific criteria for reservoir management. These criteria need not be complex; they can be limited to (1) maximum permissible reservoir level; (2) minimum permissible downstream flow rate; and (3) rules for controlling outflow (through spillway gates, turbines and municipal water-supply pumps) as a function of reservoir level, precipitation forecasts and rate of change of reservoir level. It was found through communication with the Washington Suburban Sanitary Commission that reservoir control operations were executed only on the basis of operator judgement.

The results of simulation runs, with the new reservoir management logic in place, were compared with actual experience, with respect to reservoir storage level (volume in billions of gallons of water) rather than mean daily streamflow. A correlation coefficient of 0.83 was found. The figure would probably be higher if the actual reservoir had not been allowed to exceed the upper storage limit (12.5 billion gallons), something the model does not allow. At present, the model is usable for streamflow prediction only if the actual reservoir is managed by the same criteria as those implemented in the model.

The smaller basin, above the reservoirs, was also calibrated and can be simulated. It is of less interest because it is predominantly rural, with a small rate of urbanization.

Results of simulation runs, performed at GSFC, have been provided separately to GSFC technical personnel.

SECTION 3

NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM

3.1 DESCRIPTIVE REFERENCE

The Hydrologic Research Laboratory of the National Weather Service has developed a model for use in its River Forecast Centers for streamflow prediction in large basins. It is designated NWSRFS and has been implemented at the Lower Mississippi River Forecast Center at Slidell, Louisiana. The model is a derivative of the Stanford Watershed Model IV with several modifications, including a change in the major moisture--accounting interval from one hour to six hours. A description of the model and its calibration and operation appear in the following document.

Hydrology Research Laboratory, National Oceanic and Atmospheric Administration, National Weather Service, U.S. Department of Commerce, "National Weather Service River Forecast System Forecast Procedures." NOAA TM NWS-HYDRO-14, Washington, D.C., December 1972.

3.2 WATERHSED MODELED

The NWSRFS program was acquired directly from the Hydrologic Research Laboratory. It was coded for operation on a CDC Model 6600 computer and had to be translated for operation on the IBM System/360. This was done at the IBM Huntsville facility.

Operation of the NWSRFS was verified at IBM Huntsville and at GSFC by applying it to the basin designated Monocasy River above Jug Bridge near Frederick, Maryland. Acquisition and preprocessing raw physiographic and historical data was not necessary, nor was calibration. The same basin was used as a test site by the Hydrologic Research Laboratory in developing the NWSRFS. A complete data bank for the water years 1952-61 was obtained directly from the Department of Commerce.

3.3 SUMMARY OF RESULTS

Translation of the NWSRFS, applied to the Monacasy River, was verified on the IBM System/360 Model 91 computer at GSFC. The simulation runs produced results identical to those obtained by the NWS in development of the model. Computer printouts have been provided separately to GSFC technical personnel.